

# MECHANICS TECHNOLOGY

## AREA: ELECTRICITY

### OBJECTIVES:

1. Introduce student to electrical terms and sources of electricity
2. Introduce students to practical wiring (western union splice, pigtail splice, knotted tap splice, hook end, single pole switch controlling a light)
3. Introduce student to electrical tools and devices

**TIME:** The time allotment for instruction in this area is five (5) hours.

### COMPETENCIES TO BE DEVELOPED:

1. Identify electrical tools and devices
2. Identify electrical symbols
3. Identify electrical terms
4. Identify electrical wire colors
5. Demonstrate ability to make the following:
  - a. make western union splice
  - b. make a pigtail splice
  - c. make a hook-end
  - d. wire a circuit for a single pole switch controlling a light

### REFERENCES:

*House Wiring Simplified*, by H.P. Richter/W.C. Schwan (Park Publishing)

*Agriculture Mechanics Fundamentals and Applications*, 3<sup>rd</sup> Edition by Elmer C. Cooper (Delmar)

### STUDY QUESTIONS

1. Define electricity.
2. An electrical circuit is:
  - a. an uninterrupted path of electrons along a conductor
  - b. flow of volts toward watts of current
  - c. a piece of an electrical outlet in the wall
  - d. all of the above
3. Each 120 volt electrical circuit has:
  - a. delivery (hot or live) wire
  - b. a neutral wire
  - c. a short circuit wire
  - d. both (a) and (b)
4. Electricity is distributed to branch circuits by:
  - a. an electric meter
  - b. an entrance head
  - c. a fuse
  - d. a service entrance panel
5. Tubes that carry wires are called:
  - a. cable

- b. conduit
  - c. non-metallic sheathed cable
  - d. pipe
6. A suitable wire for high temperature, high moisture locations is:
- a. type THHN
  - b. type T
  - c. type WVA
  - d. type THW
7. A cable consisting of #14 wire, one black, one red, one white, and a groundwire will be stamped:
- a. 14-2
  - b. 14-3
  - c. 14-3 w/g
  - d. 14-3 BRW
8. All electrical connections in a circuit are made:
- a. with a tape
  - b. with solder
  - c. by bolts
  - d. in boxes or fixtures
9. All metal electrical boxes must:
- a. be securely fastened
  - b. be grounded
  - c. secure the cable or conduit
  - d. all of the above
10. Neutral wires are attached to screws colored:
- a. white
  - b. silver
  - c. green
  - d. yellow
11. The device that receives electrical plugs is a:
- a. cap
  - b. box
  - c. circuit breaker
  - d. receptacle
12. In three-way switch circuits, electricity passes from one switch to the other by:
- a. neutral wires
  - b. common terminals
  - c. traveler wires
  - d. none of these
13. The most common type of receptacle is:
- a. single pole switch
  - b. duplex receptacle
  - c. 3-way switch
  - d. special outlet
14. Positive (hot) wires which carry current to appliances may be:
- a. black
  - b. blue
  - c. red
  - d. all of the above

15. Neutral wires which carry current to appliances are:
- a. red
  - b. white
  - c. green
  - d. black

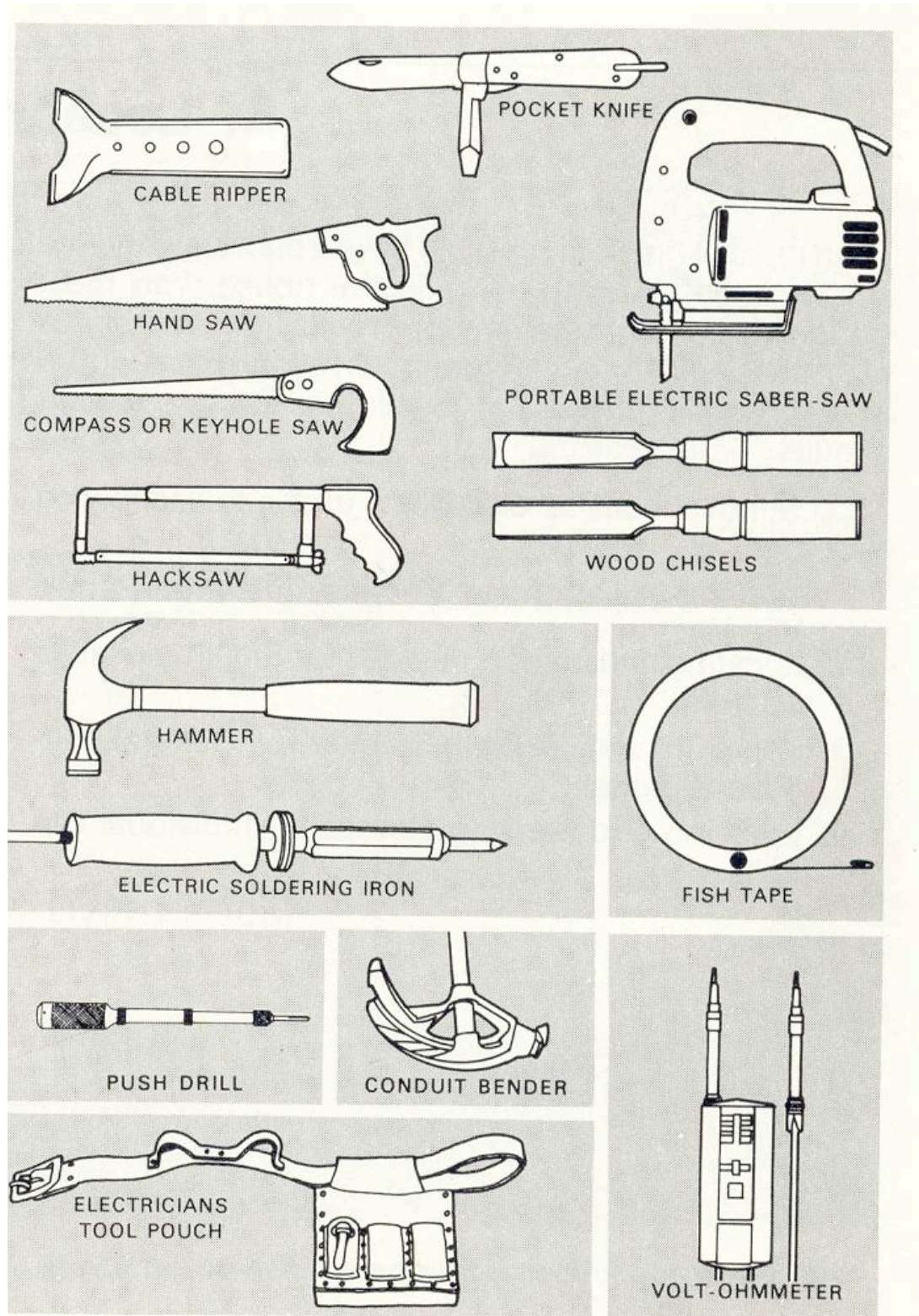
# ELECTRICITY

## INFORMATION

1. Terms and Definitions
  - a. Electricity - source of energy that can be easily converted into light, heat, or power
  - b. Ampere - unit of measure of the rate of flow of electricity through a wire
  - c. Volts - unit of measure of electrical pressure
  - d. Voltage drop - the loss in electrical pressure from its source to its point of use
  - e. Watt - unit of measure used to determine the amount of energy supplied  
 $\text{Volts} \times \text{Amperes} = \text{Watts}$
  - f. Kilowatt Hour - refers to the use of 1000 watts of electricity for one hour
  - g. Direct Current (D.C.) - current flows in one direction at a continuous rate
  - h. Alternation Current (A.C.) - current reverses at regular intervals - the most frequently used is 60 cycle
  - i. Underwriters Laboratories - an organization, nation in scope, which tests all types of wiring materials and appliances to determine whether they meet minimum standards for quality and safety
  - j. Circuit - complete path through which electricity flows, such as from the power source to a lamp, through the lamp, and back to the power source
  - k. Switch - device for opening and closing a circuit
  - l. Circuit Breaker - safety device which opens the circuit by tripping a switch
  - m. Transformer - device by which the voltage may be changed either higher or lower
  - n. Hot Wire - wires in a circuit which carry the power and which are not grounded. The wire is usually red or black.
  - o. Neutral Wire - grounded wire in a circuit (it is white or gray in color)
  - p. Short Circuit - improper connection between hot and neutral wires or between hot wires
  - q. Grounding - connection of outlets and appliances to a rod driven eight feet in the ground
  - r. Conductors - wire which carries the electricity
  - s. Cable - when two or more wires are put together inside an overall covering
  - t. Insulation - the covering placed over electrical conductors to prevent the escape of electricity
  - u. Meter - an instrument which records the amount of current used in kilowatt hours
  - v. Fuse - a safety device which burns out when the current becomes too great or a short occurs
  - w. Ampacity - the safe carrying capacity of a wire in amperes
  - x. Resistance - opposition to current flow in a conductor
  - y. Conduit - metal or plastic pipe used to house exposed wires
2. Wire Colors and Use:
  - a. Black or red - hot wire
    1. Use - carries the primary current to the consumer or between switches and consumers
  - b. White or gray - neutral wire
    1. Use - a current carrying wire that runs to every consumer a 120 volt circuit, but never to a switch or 240 volt receptacle
  - c. Bare, green, green with yellow stripes - ground wire
    1. Use - a wire for safety purposes that is not current carrying in normal situations and must attach to every device on a circuit

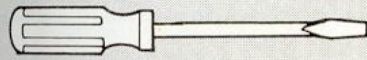
**INFORMATION**  
**TOOLS AND DEVICES**

**A. TOOLS**

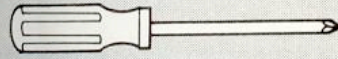




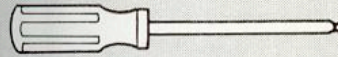
## TOOLS (CONTINUED)



FLAT BLADE SCREWDRIVER



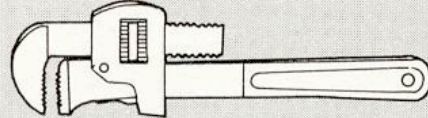
PHILLIPS SCREWDRIVER



ROBERTSON SCREWDRIVER



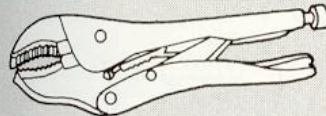
ADJUSTABLE JAW WRENCH



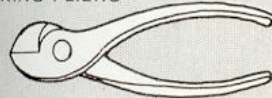
PIPE WRENCH



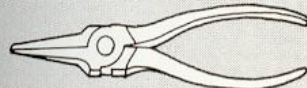
LINEMAN'S PLIERS



LOCKING PLIERS



CABLE CUTTERS

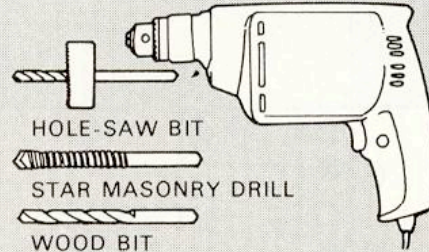


LONGNOSE PLIERS



CHANNEL-LOCK PLIERS

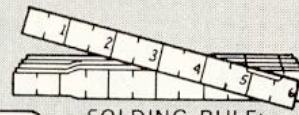
PORTABLE ELECTRIC DRILL



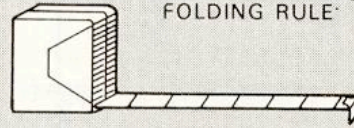
HOLE-SAW BIT

STAR MASONRY DRILL

WOOD BIT

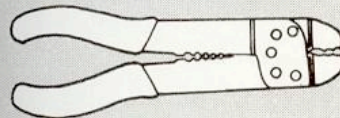


FOLDING RULE

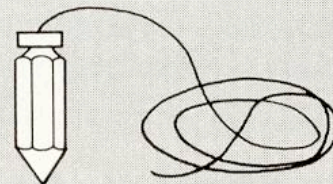


RETRACTABLE TAPE MEASURE

LEVEL



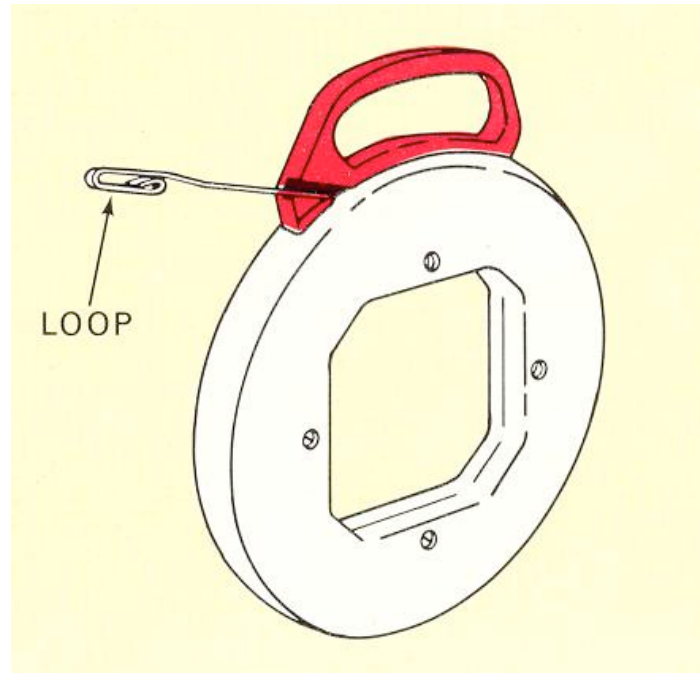
WIRE STRIPPER



PLUM-BOB

## TOOLS (CONTINUED)

### FISH TAPE

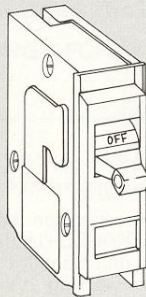


### TEST LIGHT

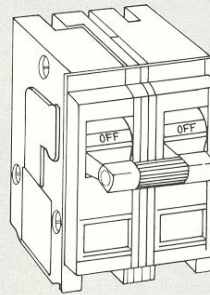


## B. OVERCURRENT DEVICES

Single-Pole Circuit Breaker



Double-Pole Circuit Breaker



Plug Fuse



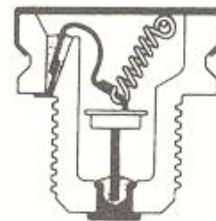
Fig. 5-2 Plug fuses are



Cartridge fuses rated 60 amp or less are of the ferrule type shown.

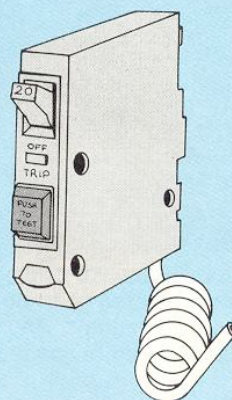


Cartridge fuses rated more than 60 amp have knife-blade terminals shown.



A typical Type-S non-tamperable fuse, and its adapter. Once an adapter has been screwed into a fuse-holder, it cannot be removed. This prevents the use of fuses larger than originally intended.

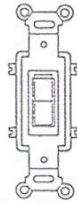
Circuit Breaker-GFCI



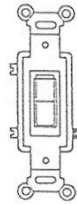


## C. SWITCHES

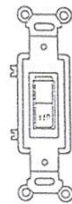
Single Pole



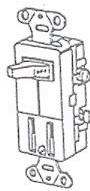
Three-Way



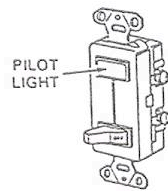
Four-Way



Switch and Receptacle



Switch and Pilot Light



Two Switches on one Strap



Push Button

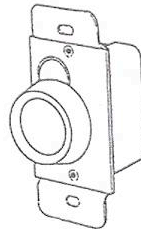


**Examples of combination switches.**

Time-Delay



Rotary Dimmer

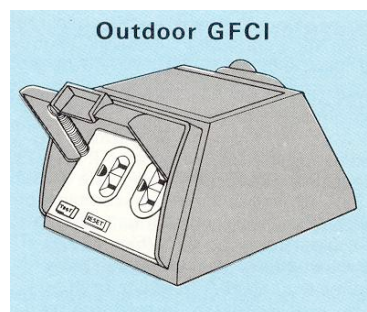
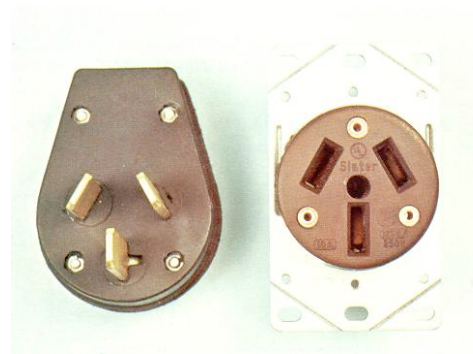
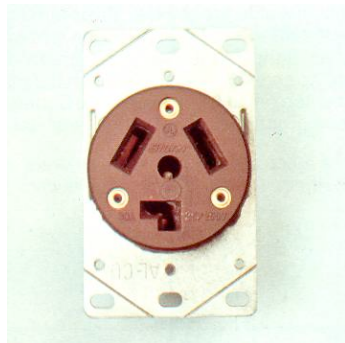
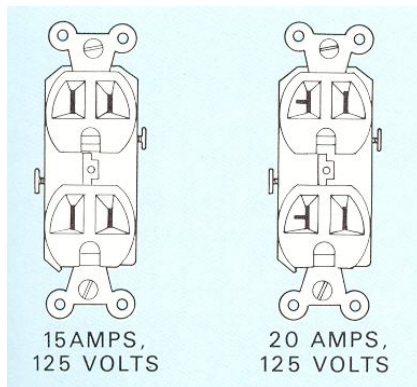


Rocker Switch



**Time-delay and dimmer switches.**

## D. RECEPTACLES

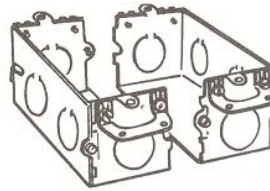


## E. BOXES AND COVERS

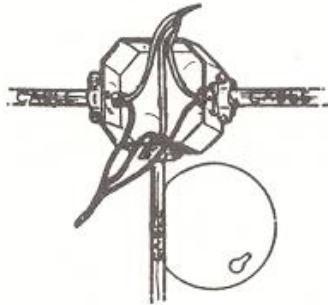
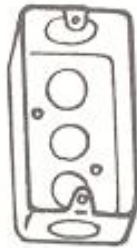
### F.



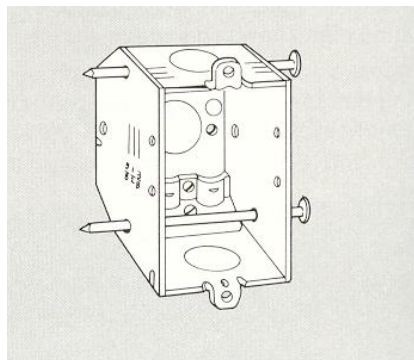
Fig. 3. The common octagonal box.



Two single boxes are easily changed into one larger "two-gang" box. Still larger boxes of 3 or 4 or more gangs are made the same way.



A junction box contains only the splices of several lengths of cable.



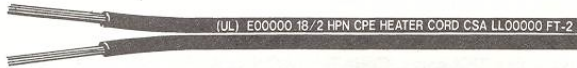
## F. WIRES AND CORDS



In Type SPT-2, the wires are imbedded in plastic. The cord is durable, attractive.



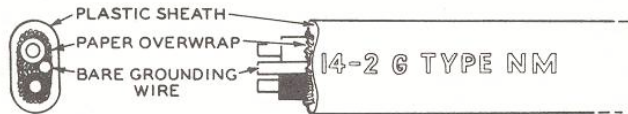
Types S and SJ cords are designed for severest use.



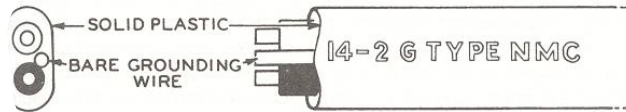
Type HPN cord is used on irons, toasters, etc.



Rubber-covered wire has rubber instead of plastic insulation. It may have a fabric or other nonmetallic flame-retardant outer covering.



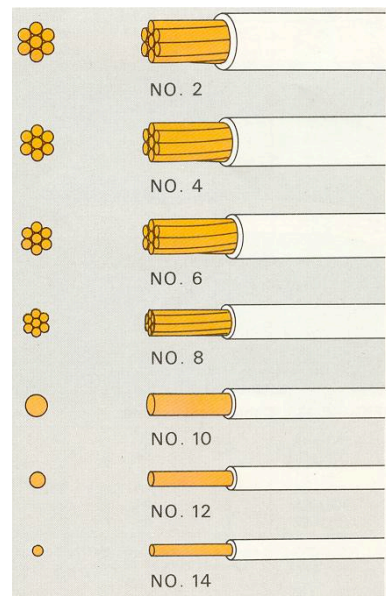
Nonmetallic sheathed cable consists of two or more individual wires, assembled into a cable. Type NM 2-wire with ground is shown, and may be used only in dry locations. The purpose of the ground wire will be explained in Chapters 7 and 10. Type NMC, for use in dry, damp, or corrosive locations, is described in Chapter 10.



Nonmetallic sheathed cable, Type NMC, may be used in dry or damp locations.

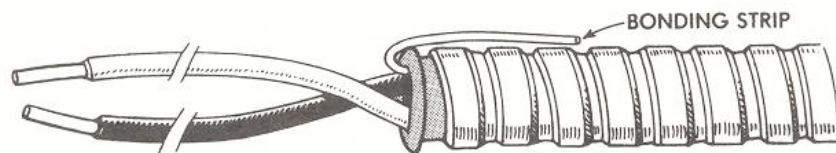
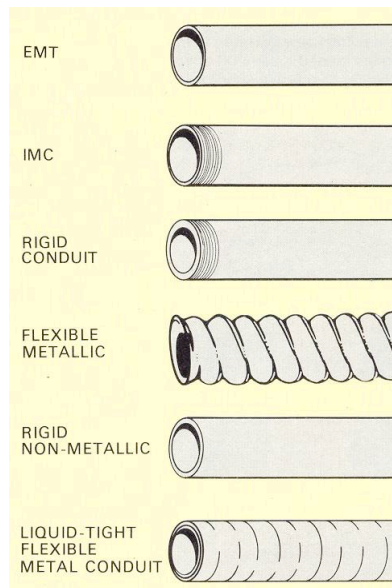


Underwriters' Type USE cable is designed to be buried directly in the ground without further protection. It is available also as 2- or 3-wire cable.





## H. CONDUIT AND ARMORED CABLE

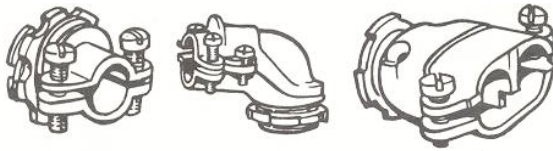


Armored cable consists of two or three wires, protected by a layer of tough paper and flexible aluminum or galvanized steel armor. Note the bonding strip under the armor.

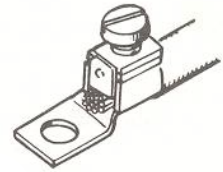


Flexible conduit is installed in the same way as armored cable, but wires are pulled into place later.

## H. CONNECTORS AND CLAMPS



Connectors used in anchoring cable to boxes.

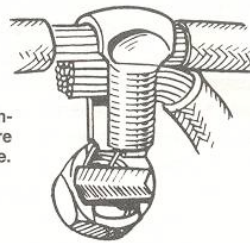


Solderless connectors of this type are used with heavy sizes of wire.

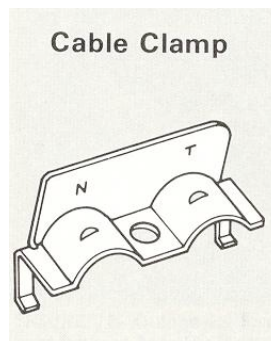
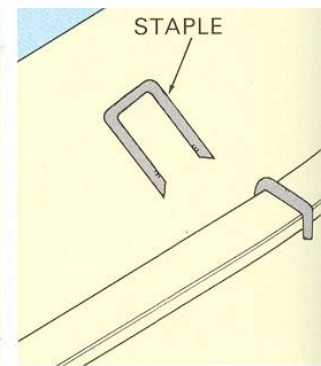
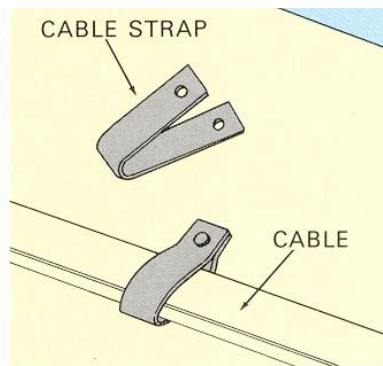
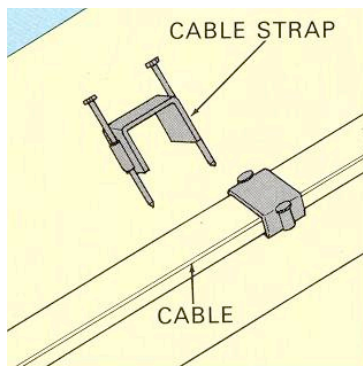
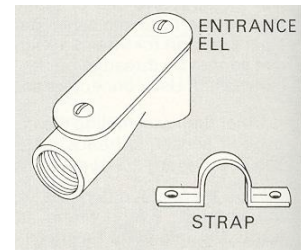
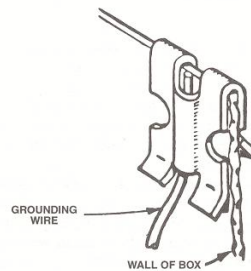
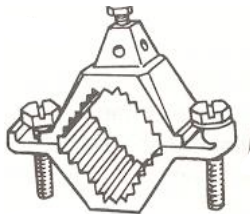






















































For heavier wires, use metal connectors. They must be taped.

Use this split-bolt connector when splicing a heavy wire to another continuous heavy wire.



Solderless connector "wire nut"



	CEILING OUTLET		TWO-WIRE CABLE OR RACEWAY
	WALL BRACKET		THREE-WIRE CABLE OR RACEWAY
	LAMPHOLDER WITH PULL SWITCH		FOUR-WIRE CABLE OR RACEWAY
	FLOOR OUTLET		PUSH BUTTON
	CEILING OUTLET FOR RECESSED FIXTURE. (OUTLINE SHOWS SHAPE OF FIXTURE)		BUZZER
	TELEVISION OUTLET		BELL (OR  )
	FAN OUTLET		CHIME (ALSO  )
	RANGE OUTLET		ANNUNCIATOR
	SPECIAL PURPOSE OUTLET (SUBSCRIPT LETTERS INDICATE FUNCTIONS: DW-DISHWASHER, CD-CLOTHES DRYER, ETC. ALSO a, b, c, d, ETC. SEE SPECIFICATIONS)		INTERCONNECTING TELEPHONE
	SINGLE RECEPTACLE OUTLET		OUTSIDE TELEPHONE
	DUPLEX RECEPTACLE OUTLET		CLOCK
	TRIPLEX RECEPTACLE OUTLET		MOTOR
	DUPLEX RECEPTACLE OUTLET, SPLIT CIRCUIT		TRANSFORMER
	WEATHERPROOF RECEPTACLE OUTLET		JUNCTION BOX
	CONVENIENCE OUTLET OTHER THAN DUPLEX. 1 = SINGLE, 3 = TRIPLEX, ETC.		GROUND CONNECTION
	FLUORESCENT FIXTURE (EXTEND RECTANGLE TO SHOW LENGTH)		LIGHTING PANEL
	SINGLE-POLE SWITCH		POWER PANEL
	DOOR SWITCH		ELECTRIC DOOR OPENER
	DOUBLE-POLE SWITCH		BATTERY
	THREE-WAY SWITCH		SWITCH LEG INDICATION, CONNECTS OUTLETS WITH CONTROL POINTS
	FOUR-WAY SWITCH		THERMOSTAT
	SWITCH WITH PILOT		HEATING PANEL
	WEATHERPROOF SWITCH		MULTIOUTLET ASSEMBLY ARROWS SHOW LIMITS OF INSTALLATION. APPROPRIATE SYMBOL INDICATES TYPES OF OUTLET. SPACING OF OUTLET IS INDICATED BY X INCHES.
	DIMMER SWITCH		SWITCH AND FUSE
			OVERCURRENT DEVICE (FUSE, BREAKER, THERMAL OVERLOAD)
			CIRCUIT BREAKER

\*IF THERE IS AN ARROW ON THE CABLE,  
IT INDICATES A HOME RUN.

NOTE: A letter G signifies that the device is of the grounding type. Since all receptacles on new installations are of the grounding type, the notation G is often omitted for simplicity.

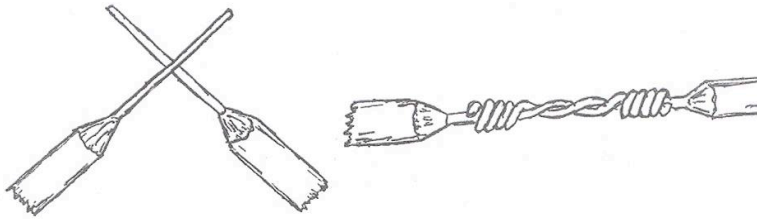
NOTE: A letter G signifies that the device is of the grounding type. Since all receptacles on new installations are of the grounding type, the notation G is often omitted for simplicity.

## D. EXERCISES

### EXERCISE A: Western Union or End Splice

1. Remove 3 inches of insulation from wires
2. Clean wires with knife before crossing them
3. Wind one end around other wire toward insulation
4. Keep windings close together (about 4 or 5 windings)
5. Make duplicate windings with other free wire
6. Cut excess wire close to splice leaving no sharp ends

FIGURE I



### EXERCISE B: Knotted Tap Splice

1. Remove 1 1/4" insulation on main wire
2. Remove 3" insulation from tap wire
3. Scrape wires clean
4. Start knot with tap wire crossing close to insulation on main wire
5. Make knot with tap wire, insulation near the main wire
6. Complete knot and wind tightly

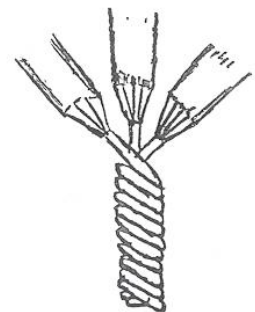
FIGURE II



### EXERCISE C: Pigtail Splice

1. Correctly remove insulation from three wires
2. Clean wires with knife
3. Holding bare wire ends together, begin twisting all three wires together
4. Twist until windings are close to insulation
5. Solder to insure good permanent splice

FIGURE III



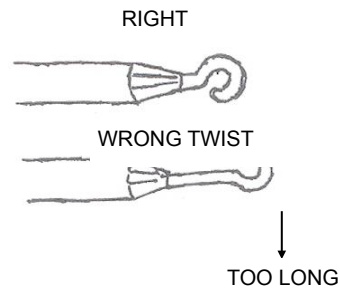
### EXERCISE D: Hook End of Wire

1. Remove 1 1/4" insulation from wire



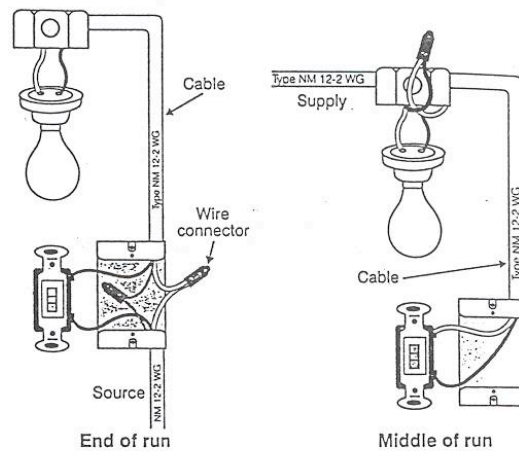
2. Make hook in bare wire so it centers in line with wire
3. Make sure loop is made so a terminal screw tightens loop instead of spreading it

**FIGURE IV**



### EXERCISE E: Single Pole Switch Controlling a Light

**FIGURE V**



1. Obtain material needed: 1 light fixture, 1 ceiling box, 1 wall box, 1 single pole switch, 2 pieces of 12-2 wire 2' long, 1 switch cover
2. Determine if the switch has screw terminals or push-in terminals. (Note: both terminals will be brass-colored. A single pole switch is only connected to hot wires.)
3. Prepare the wire
4. Connect the wire with black insulation to one of the brass-colored terminals
5. Connect the wire with the white insulation to the other brass-colored terminals. (Note: put a piece of black tape around the insulation on this wire. This will indicate to anyone working on the switch that it is a "hot" wire.)
6. Connect the un-insulated wire to the grounding screw (green)
7. Place the switch in the outlet box and attach with screws
8. Place the switch cover over the switch and attach to the switch